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Natural Farming and Mulching Synergies: Enhancing Soil Health and Crop Productivity in Indian Agroecosystems

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Mulching is a foundational component of Indian natural farming, deeply rooted in traditional ecological practices and increasingly recognized for its multifaceted benefits in sustainable agriculture. By covering soil with organic materials such as straw, leaf litter, green manures, or locally sourced biomass, mulching aids in conserving soil moisture, suppressing weeds, regulating temperature, and enriching soil organic carbon. This practice not only supports crop growth under variable climatic conditions but also enhances microbial activity and soil biodiversity. In Indian natural farming, mulching is not an isolated technique—it operates in close synergy with indigenous bio-inputs like Jeevamrit and Bijamrut. These microbial inoculants perform more effectively when soils are mulched, as the stabilized microenvironment supports microbial proliferation and nutrient cycling. Drawing from a wide range of peer-reviewed research, empirical data, and regional farmer-led case studies, this review explores the ecological logic, practical applications, and regional adaptations of mulching across diverse agro-climatic zones in India. It also identifies key constraints in adoption, such as biomass scarcity and labor intensity, while highlighting innovative local solutions. Overall, the paper positions mulching as a linchpin in the Indian natural farming system, advocating for greater scientific attention, policy support, and integration into sustainable agriculture strategies aimed at enhancing resilience and reducing external input dependence.

Introduction

India's agrarian culture is deeply embedded in nature-inspired farming practices and traditional ecological knowledge. Over the past century, the country has undergone profound changes in its agricultural systems—beginning with the Green Revolution, which introduced high-yielding crop varieties and chemical inputs, and more recently, through a conscious return to nature-centric farming approaches like Indian Natural Farming. This shift is not merely ideological; it is a response to critical challenges such as soil degradation, rising input costs, water scarcity, and ecological imbalance.

Indian Natural Farming (INF) emphasizes low-cost, chemical-free, biodiversity-enhancing agriculture rooted in locally available resources and traditional knowledge. Core components include the application of Bijamrut for seed treatment, Jeevamrit for enriching soil microbial life, and mulching (Acchadana) for maintaining soil cover and health. While the biological and agronomic benefits of Jeevamrit and Bijamrut have been well established through recent studies (Lakhani, 2024; Lakhani *et al.,* 2025), mulching remains comparatively under-researched despite being widely practiced and deeply integrated into natural farming systems.

Mulching serves as more than just a protective ground cover; it plays a crucial role in moisture conservation, weed suppression, organic matter decomposition, and the creation of a microclimate conducive to microbial proliferation. As such, its contribution to crop productivity and ecosystem stability is substantial. Yet, academic attention to its role remains limited, especially in the context of Indian agroecology and regional farming adaptations.

This review aims to elevate mulching from a supporting practice to a central component of INF by critically examining its ecological, agronomic, and socio-economic dimensions. Drawing on both historical traditions and contemporary scientific research, the paper synthesizes existing literature, empirical data, and farmer-led case studies to provide a comprehensive understanding of mulching's function and potential in promoting sustainable and resilient agriculture across India.

Certainly! Below is an elaborated version of the section “Natural Farming in India: Principles and Practice” extended to approximately 1500 words**,** retaining all references and expanding on key themes for depth and detail:

Natural Farming in India: Principles and Practice

The resurgence of natural farming in India marks a critical transition away from external-input-intensive agriculture toward a self-reliant, ecologically harmonious model rooted in traditional wisdom and modern agroecological understanding. As the country grapples with pressing concerns such as soil degradation, water scarcity, declining farm incomes, and rising chemical dependency, Indian Natural Farming (INF) emerges as both a philosophical return to roots and a scientifically informed approach to sustainable agriculture.

Unlike certified organic farming—which often permits market-sourced organic inputs such as packaged composts, biopesticides, or certified amendments—Indian natural farming is designed to be fully self-sustaining. It emphasizes the use of on-farm resources including indigenous cow dung, cow urine, crop residues, and locally available biomass. The core principle behind this approach is to foster a closed-loop agricultural system where the farm’s internal resources provide the inputs needed for fertility, protection, and productivity.

The foundation of Indian natural farming is built on four interlinked pillars: Bijamrut (a seed treatment solution), Jeevamrit (a fermented microbial culture for soil enhancement), mulching (Acchadana), and Waaphasa (soil aeration or moisture balance). These are further supported by practices like intercropping, biodiversity promotion, and minimal tillage.

Reclaiming Ecological Balance through Natural Inputs

The overarching aim of natural farming is to restore ecological balance by minimizing disturbance to the soil, preserving microbial life, and allowing natural cycles—such as nutrient cycling and predator-prey interactions—to function without synthetic interference. Soil health is given utmost priority, with particular emphasis on improving organic matter content and supporting the living biological systems within it.

According to Lakhani *et al.,* (2020b), natural farming has the capacity to rejuvenate soil fertility, reduce the cost of cultivation, and free farmers from the economic burden of synthetic fertilizers, pesticides, and market-reliant inputs. In their foundational overview of the Indian natural farming movement, the authors observed that farmers practicing natural methods reported significantly better soil structure, more granular texture, and a substantial increase in earthworm populations—often seen as an indicator of healthy, living soil. Mulching, as a key practice in these systems, was linked directly to these improvements by promoting conditions conducive to soil life.

Role of Bijamrut and Jeevamrit

Two unique bio-inputs underpin the fertility strategy of Indian natural farming: Bijamrut and Jeevamrit. These preparations exemplify the indigenous technical knowledge (ITK) harnessed by Indian farmers and modernized for wider scientific scrutiny.

Bijamrut, as reviewed by Lakhani (2024), is used primarily as a seed treatment. It is made using cow dung, cow urine, lime, and a bit of soil from the farm bund, often fermented for a short duration. The role of Bijamrut is to detoxify seeds that might have been exposed to chemical coatings and to inoculate them with beneficial microbes. This not only improves germination but also enhances early-stage disease resistance and root vigor.

Jeevamrit, on the other hand, is a liquid microbial inoculant typically made by fermenting a mixture of fresh cow dung, cow urine, jaggery, gram flour, and water. The formulation is rich in a wide spectrum of microbial consortia, including bacteria, fungi, and actinomycetes, which enhance nutrient availability, decompose organic matter, and improve the soil's biological activity. As Lakhani (2024a) discusses, the routine application of Jeevamrit results in increased microbial biomass, heightened enzymatic activity, and a marked improvement in nutrient cycling within the rhizosphere.

Importantly, both of these formulations operate most efficiently under field conditions that maintain stable moisture, moderated temperatures, and adequate organic matter—conditions that are optimally maintained through the practice of mulching**.**

Integration of Mulching: The Third Pillar

Mulching, referred to as *Acchadana* in traditional texts, is the application of organic residues—such as straw, crop stubble, fallen leaves, or green plant material—on the soil surface. It serves as both a protective layer and a slow-releasing nutrient source. In the natural farming framework, only biodegradable, locally sourced materials are used. This practice is particularly crucial in dryland and rain-fed areas where evaporation losses are high and irrigation is either limited or unavailable.

The ecological benefits of mulching are manifold:

Moisture Conservation: Organic mulch reduces surface evaporation by shielding the soil from direct sunlight and wind. According to Ranjan *et al.,* (2020), mulched soils retain 60–80% more moisture compared to bare soils in rain-fed agriculture.

Weed Suppression: As noted by Chopra & Koul (2020), mulch inhibits weed growth by blocking light, thereby reducing the need for manual or chemical weeding.

Temperature Regulation: Krishnan (2023) reported that mulching significantly moderates soil temperatures, buffering roots against extreme diurnal temperature fluctuations and protecting microbial communities.

Improved Soil Biology: Organic mulches, as they decompose, become a habitat and food source for earthworms and beneficial microorganisms. Sharma *et al.,* (2023) emphasized that farmers who practiced mulching noted enhanced root development and better foliage quality.

Soil Carbon Sequestration: Devarinti (2016) argued that regular mulching enhances the slow return of carbon to the soil, contributing to humus formation and long-term fertility.

Lakhani *et al.,* (2025) further explored the synergistic relationship between mulching and Jeevamrit, highlighting how mulched soils provided the ideal microhabitat for microbial proliferation. This interaction not only improved nutrient availability but also reduced the frequency of irrigation—crucial for resource-constrained farmers.

Traditional Wisdom Validated by Science

Indian farmers have historically used mulching in various forms, particularly in regions with limited water availability. Tribal and dryland communities often used fallen leaves, dry grasses, and cleared weeds to retain soil moisture and suppress pests. These practices were not documented in formal agronomic literature until recently.

Chakraborty *et al.,* (2016), for example, demonstrated that bio-mulching using rice straw and leaf litter in rain-fed mulberry plantations significantly enhanced both soil moisture and leaf yield in West Bengal's lateritic soils. Bhati and Bishnoi (2017), in their study of natural farming systems, emphasized the contribution of mulching to soil organic matter restoration and long-term fertility buildup.

Similarly, Sharma *et al.,* (2023) consolidated multiple farmer case studies across Indian states and found that mulching, when used in conjunction with Jeevamrit, led to stronger root systems, healthier crop growth, and better resistance to pests and diseases.

Farmer-Centric Evidence and Grassroots Innovations

In addition to scientific validation, participatory research and field surveys have provided strong ground-level evidence of mulching's efficacy. Aulakh *et al.,* (2022), in a study on farmer perceptions in North-West India, found that over 70% of natural farming practitioners ranked mulching as one of the most cost-effective and beneficial interventions. Reported benefits included reduced herbicide usage, better soil moisture during drought periods, and yield gains of 15–30%.

In Andhra Pradesh, Kumar *et al.,* (2020) documented the widespread use of Azolla as a living mulch in paddy fields. This aquatic fern not only covered soil and conserved moisture but also fixed nitrogen through its symbiosis with cyanobacteria.

In Himachal Pradesh, as per Choudhary *et al.,* (2022), farmers utilized pine needles and maize stubble as mulch to prevent frost damage in high-altitude pea cultivation.

These region-specific adaptations highlight the flexibility of mulching as a practice. Unlike standardized inputs, mulching materials and techniques can be adjusted to suit climate, crop, and local biomass availability—making it both context-sensitive and farmer-driven.

Mulching as a Systemic Connector

A key insight from recent research is that mulching does not act in isolation but functions as a facilitator of other natural farming inputs. When Jeevamrit is applied on a mulched field, the moisture retention and temperature buffering provided by the mulch improve microbial survival and colonization rates (Lakhani *et al.,* 2025).

Similarly, when seeds treated with Bijamrut are sown into mulched soils, early seedling stress is minimized, leading to better emergence and initial growth (Lakhani, 2024).

Sharma *et al.,* (2023) emphasized this interconnectedness, stating that the success of Indian natural farming lies in the synergy among its components—where mulching acts as a physical and biological interface, linking inputs like Jeevamrit and Bijamrut with the soil ecosystem.

Types and Materials Used for Mulching in Indian Natural Farming

In Indian natural farming, materials for mulching are chosen using considerations of ecological compatibility, locality of availability, and biodegradable nature.

In contrast to other systems where plastic mulch can be utilized, Indian natural farming exclusively advocates for biodegradable mulches that break down naturally, add humus to the soil, and favor microbial life (Lakhani *et al.,* 2025; Devarinti, 2016).

The crop residues are usually sourced as biomass for mulching from leaf litter, green manures, or tree loppings, depending on the season of availability and the regional crops. Material selection for the process of mulching is regulated by the decomposition rate of the materials, their moisture-holding capacity, and their effect on soil temperature and weed control (Ranjan *et al.,* 2020; Sharma *et al.,* 2023).

These types of mulch have various agronomic advantages along with suitability for customization as per cropping patterns and agroclimatic conditions. For instance, using Azolla as paddy field green mulch not just saves moisture but also supplements nitrogen in the form of cyanobacterial symbionts (Kumar *et al.,* 2020).

Scientific research has proven that leaf litter mulch stimulates microbial respiration, enhances the ability of the soil to exchange cations (CEC), and sustains fungi-dominant soil communities vital for perennials (Sharma *et al.,* 2023; Krishnan, 2023).

Agronomic and Ecological Effects of Mulching

Mulching changes significant soil-plant-atmosphere relationships. Its primary roles are to manage soil temperature, stop moisture loss through evaporation, control soil erosion, manage weed germination, and promote soil biota.

Experimentation validates the fact that plots with mulch have much higher soil moisture levels as opposed to bare soils. Mulches also lower day-to-day temperature variations, provoking optimal environments for root development and microbial occupancy (Ranjan *et al.,* 2020; Sharma *et al.,* 2023).

Table.1 Types of Organic Mulch Used in Indian Natural Farming

Type of Mulch	Source Material	Common Crops	Regions Practiced
Dry Straw Mulch	Wheat/paddy straw	Legumes, vegetables	Punjab, Haryana, Uttar Pradesh
Leaf Litter Mulch	Neem, mango, bamboo leaves	Fruit crops, spices	Odisha, Chhattisgarh, Maharashtra
Green Live Mulch	Cowpea, Azolla, dhaincha, sunhemp	Paddy, pulses	Andhra Pradesh, Karnataka
Weed-Based Mulch	Cleared native weeds (sun-dried)	Millets, maize	Gujarat, Madhya Pradesh
Tree Branch Loppings	Subabul, Gliricidia, moringa branches	Orchards	Tamil Nadu, Gujarat, Kerala
Sugarcane Trash	Cane residues post-harvest	Sugarcane, turmeric	Maharashtra, UP, Telangana

Sources: Ranjan *et al.,* (2020); Lakhani *et al.,* (2020b); Kumar *et al.,* (2020); Sharma *et al.,* (2023)

Table.2 Comparative Agronomic Parameters Under Mulched vs. Non-Mulched Conditions

Agronomic Parameter	Mulched Plots	Non-Mulched Plots	% Change
Soil Moisture (%)	18–22	10–12	↑ 60–80%
Soil Temperature (°C)	26.4 ± 1.5	32.7 ± 2.3	↓ ~20%
Soil Organic Carbon (%)	0.74–1.10	0.38–0.51	↑ 45–100%
Earthworm Density (no/m²)	175–230	90–120	↑ 50–100%
Weed Biomass (g/m²)	180–220	480–600	↓ 60–70%
Crop Yield (kg/ha)	1800–2200	1400–1600	↑ 25–35%

Sources: Sharma *et al.,* (2023); Krishnan (2023); Lakhani *et al.,* (2025); Devarinti (2016)

Table.3 Synergistic Role of Mulching with Jeevamrit and Bijamrut

Component	Role	Synergy with Mulching
Jeevamrit	Soil microbial booster	Enhances colonization due to temperature stability
Bijamrut	Seed treatment and pathogen inhibitor	Reduced seedling shock in mulched microclimates
Mulching	Soil cover and microhabitat builder	Provides ideal environment for microbial survival

Sources: Lakhani *et al.,* (2024); Sarma *et al.,* (2023); Sharma *et al.,* (2023)

Table.4 Regional Case Studies of Mulching Practices

Region	Mulching Strategy	Reported Outcomes
Andhra Pradesh	Azolla used in paddy bunds as living mulch	Yield ↑ 28%, Water Use ↓ 32% (Kumar *et al.,* 2020)
Himachal Pradesh	Pine needle mulch for frost protection in peas	Frost damage ↓ 70% (Choudhary *et al.,* 2022)
Maharashtra	Sugarcane trash used in turmeric and cotton fields	Weed burden ↓ 65%, SOC ↑ (Sharma *et al.,* 2023)
Gujarat	Subabul branch mulch in orchards	Enhanced moisture retention, pest suppression

Table.5 Key Constraints and Mitigation Strategies

Constraint	Impact	Recommended Solution
Biomass scarcity	Mulching ineffective in arid zones	Promote cover crops, agroforestry biomass
Labor-intensive application	Reduced adoption in large farms	Mechanized mulching tools, farmer collectives
Pest harboring in mulch	Crop damage	Neem smoke rings, spacing practices
Knowledge gaps	Suboptimal mulch use	KVK-led farmer training programs

Sources: Korav *et al.,* (2020); Sharma *et al.,* (2023); Krishnan (2023)

The effect on yield is especially significant. Growers adopting mulching in pulse and turmeric indicated yield increase of 25–30% due to lowered plant stress, improved water usage, and nutrient cycling (Krishnan, 2023). The increase in earthworm population is an essential ecological marker of soil health recovery (Lakhani *et al.,* 2025).

Synergy Between Mulching and Bio-inputs: Jeevamrit & Bijamrut

Mulching in Indian natural farming is not applied in isolation but works synergistically with key microbial inputs like Jeevamrit and Bijamrut.

Jeevamrit—a fermented mixture of cow dung, urine, jaggery, and gram flour—contains diverse microbial consortia that thrive under the shaded, moist conditions provided by mulching (Lakhani *et al.,* 2024a).

When Jeevamrit was applied to mulched maize plots, microbial respiration increased by 40% compared to non-mulched controls (Sharma *et al.,* 2023). Bijamrut-treated seeds planted in mulched soils also displayed better root vigor and higher germination (Lakhani, 2024).

Farmer Innovations and Regional Case Studies

Farmers in India have used context-dependent mulching practices that rely upon existing biomass, soil, and crop needs. Such localized practices express the agroecological adaptability of natural farming systems. These regional adaptations highlight farmer-led innovation in Indian natural farming.

Mulching provides a means for integration with agroforestry, intercropping, and cover cropping, which allows farmers to receive multiple ecosystem benefits from limited inputs.

Challenges and Constraints in Mulching Adoption

Notwithstanding its benefits, universal adoption of mulching is not forthcoming. Barriers such as biomass availability, labour requirement, rodent nesting, as well as unavailability of scientific training, hamper its wider implementation. Researchers and policymakers should promote on-farm trials, demonstrations, and input biomass management plans to overcome these adoption barriers.

Mulching, a core component of Indian natural farming, plays a pivotal role in fostering ecological resilience and sustainable crop production. This review underscores the multifaceted benefits of mulching—ranging from conserving soil moisture, regulating temperature, suppressing weeds, and enhancing soil organic carbon to supporting microbial biodiversity and improving crop yields. Unlike conventional methods, Indian natural farming promotes the use of biodegradable, locally sourced mulching materials, aligning with low-input, eco-friendly practices. Scientific studies and farmer-led innovations demonstrate that mulching, when combined with bio-inputs like Jeevamrit and Bijamrut, creates optimal conditions for microbial activity, nutrient cycling, and root development. Regional adaptations, such as the use of Azolla in paddy fields or pine needles in frost-prone regions, highlight the flexibility and relevance of mulching across India's diverse agro-climatic zones. Despite its proven advantages, adoption is hindered by constraints including biomass scarcity, labor intensity, pest risks, and knowledge gaps. These challenges call for targeted interventions—such as mechanized mulching tools, training through Krishi Vigyan Kendras (KVKs), and promotion of cover crops for biomass generation. To fully harness its potential, mulching must be recognized not as a peripheral practice but as a central strategy in natural farming. Future research should focus on its long-term agronomic impacts, while policy frameworks must integrate it into climate-resilient and low-cost farming models. In sum, mulching offers a low-tech, high-impact solution to several of India's agricultural challenges. Its broader adoption can significantly contribute to soil health restoration, resource efficiency, and farmer livelihood improvement in a sustainable and self-reliant manner.

Author Contributions

Hardik lakhani: Investigation, formal analysis, writing—original draft. Neha Bodar: Validation, methodology, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

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